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**On-Line Digitizing of
Salinity-Temperature-Pressure
Data with a
Shipboard Computer**

by **A. Huyer and C. A. Collins**
Marine Sciences Branch
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Mines & Resources

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TECHNICAL REPORT NO. 152

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DATA WITH A SHIPBOARD COMPUTER

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1. Introduction

A small computer manufactured by Hewlett-Packard was used to digitize the analog signals of a temperature-salinity-pressure instrument (Bissett-Berman, model 9040 or 9006 STD). This digitizing system was successfully used at sea in May and October, 1969. The purpose of this manuscript is to describe this digitizing system (hardware) and associated computer programs (software).

2. Description of the hardware

A block diagram of the system is shown in Fig. 1. The Bissett-Berman model 9006 STD measures underwater temperature, conductivity and pressure. Conductivity is converted to salinity in the underwater unit; compensation is made for first and second order temperature effects and first and second order pressure effects (Brown, 1964). Pressure is scaled to depth (Collins, 1969). The output from each underwater sensor is a frequency; these are mixed and transmitted to the deck unit. The three frequencies are separated in the deck unit where they are used to drive an analog recorder and are available for digitizing.

The heart of the digitizing system is a Hewlett-Packard 2115A computer which has 16-bit words, an 8K memory and eight input-output channels. Seven of the input-output channels are used as follows: teletype (HP 2752A), photo-reader (HP 2737A), high-speed paper tape punch (HP 2753A), reed scanner (HP 2912A), digital voltmeter (HP 2401C) input and output, and time base generator (HP 12539A). A software "driver" was provided with each of these peripheral units. Each peripheral is assigned an octal unit reference number and an octal input-output (I/O) channel number.

Table 1 lists the peripheral units, the associated drivers, their unit reference numbers, and the I/O channel numbers as used in May and October, 1969. The I/O channel number of a peripheral device can be changed simply by moving the interface board in the input-output frame. This may be done at any time and is called "reconfiguration"; it necessitates configuring some of the standard software (see Appendix B). It may be desirable to reconfigure the system when new peripherals are added, or when the priorities are changed, since peripheral units with lower I/O channel numbers may interrupt those with higher I/O channel numbers.

The digitizing system may be programmed in Algol, Fortran or an assembly language. Source programs are punched on the teletype and compiled in two passes. Result of compilation is a relocatable binary tape. Software known as the BASIC CONTROL SYSTEM is used to run the program or to produce an absolute binary tape which is loaded alone to run the program.

3. The digitizing program (DEEP)

3.1 Description

The program for digitizing data obtained by the STD was written in Fortran, and an absolute binary tape was produced. This tape is referred to as program DEEP. The program provides for: entering station heading data via the teletype; scanning the three STP signals and determining the frequency of each; converting the frequencies to parameter values (decibar, ppt and °C) and punching these onto paper tape. It is necessary to determine each frequency to ± 1 Hz and this takes one second. (Corresponding parameter precisions are: ± 1 db, ± 0.003 ppt, and $\pm 0.02^\circ\text{C}$). The three determinations are sequential; vertical separation of the data depends on the rate at which the underwater unit is lowered. Program DEEP uses two subroutines: CAST, which measures the STP frequencies and converts them to parameter values, and the BAILEY CLOCK ROUTINE which keeps the time used to initialize each set of measurements. The BAILEY CLOCK ROUTINE was provided by the manufacturer but it is not standard software; for this reason it is described in an appendix.

The program DEEP (Table 2) requests heading data for each STP station (Fig. 2). It sets and reads a clock maintained through the BAILEY CLOCK ROUTINE. When a certain time interval has elapsed a call to CAST (Table 3) provides a new measurement of the parameters. The data are stored and compared to the previous set. If the pressure is unchanged, the temperature and salinity data are averaged. If the pressure has decreased, the stored temperature value is updated. When the pressure has increased, the previous set of data are output and a correction depending on the temperature gradient is made to the data (Gaul, 1968). Reading of the frequency signals is discontinued when a specified maximum pressure is exceeded, or it may be discontinued earlier by setting switch 15 of the computer's switch register to 1. At the end of the cast, parameter values 4000 db, 0°C and 0 ppt are punched on the data tape.

Whenever CAST is called from the main program, the three STP frequencies are read sequentially and returned as parameters to the main program. The scanner channels must be connected to the STP output signals as specified in the listing of CAST (Table 3), e.g. channel 1 to pressure, channel 2 to temperature and channel 3 to salinity. Unit reference numbers are assigned as in Table 1.

CAST works as follows: The hold-off is removed from the data source interface with a WRITE statement. The voltmeter is programmed to read frequencies with the variable IPGM. The reed scanner is switched with a WRITE statement which includes a channel number and a delay time, variable ISPCM. The data are returned to the computer with a READ statement. Minor changes to both CAST and DEEP are necessary for STP systems with different temperature or salinity ranges, or a different zero pressure error.

3.2 Operating procedures

These instructions are for the absolute binary tape of DEEP. Procedures for preparing an absolute tape are described in Appendix A.

1. With the computer off, make sure that the interface boards of the peripheral units are in the input-output channels shown in Table 1.

2. Connect STP frequency outputs to the scanner as follows:

Pressure	Channel #1
Temperature	Channel #2
Salinity	Channel #3

3. Connect scanner frequency output (Channel \emptyset) to digital voltmeter frequency input (J9 or on front panel). Connect J8 of scanner to J31 of digital voltmeter.

4. Turn on digital voltmeter, scanner, STP deck unit.

5. Set scanner controls:

RESET/START	on EXT
MODE	on MON
SYSTEM CONTROL	on REMOTE

6. Set voltmeter controls:

FUNCTION	to EXT SEL
SAMPLE PERIOD	to EXT SEL
SAMPLING RATE	fully clockwise
RANGE	to any position except INT-1V, INT + 1V, or ZERO
ATTENUATION	at about middle of range

7. Turn on computer and photo-reader.
8. Place absolute binary tape of DEEP in the photo-reader with the narrow portion of the tape toward the photo-reader. Thread the leader portion of the tape through the brake, under the hold-down spring and under the rubber roller. Raise the tape guide until RUN is exposed.
9. Set the computer switch register to 177 $\emptyset\emptyset$.
10. Press LOAD ADDRESS.
11. Set LOADER switch to ENABLED.
12. Press PRESET.

13. Press RUN. The tape is read through the photo-reader. When it stops the T-register should contain 102077. If not, see note below
14. Set LOADER switch to PROTECT.
15. Remove tape from photo-reader and rewind it.
16. Turn teletype to LINE, and turn high-speed punch on. Press the white button on the punch to produce some leader and thread the tape so it will be wound onto the spool. Check to make sure there is sufficient paper tape on the supply reel.
17. Set switch register to 2000 (switch 10 up and all other switches down).
18. Press LOAD ADDRESS.
19. Press RUN.
20. Teletype prints ENTER TIME (HRS: MIN: SEC). Type in the Greenwich mean time in hours, minutes and seconds, separating them with a space, comma or colon. Type keys marked RETURN and LINE FEED. Computer halts. Press RUN.
21. Enter heading data as requested. Separate the data by a space or comma. After each response check that there is no error. If an error was made, type the key labelled RUB OUT and then RETURN, LINE FEED, and repeat the entire line. If there is no error, type RETURN, LINE FEED.

Teletype prints

Response

CRUISE NUMBER

The last part of the cruise number, e.g. 006.

CONSECUTIVE STATION NUMBER

An integral number.

DATE (YEAR, MONTH, DAY)

The date (GMT).

LATITUDE - DEGREES MINUTES

Numerics only. Do not use the sign.

LONGITUDE - DEGREES MINUTES

Numerics only. Do not use positive and negative signs as no space has been left for them on the data tape.

TIME INTERVAL BETWEEN READINGS IN SEC

At least 3.6 seconds.

MAXIMUM PRESSURE TO BE OBSERVED

The pressure in decibars.

WHEN READY TO BEGIN CAST PUSH RUN

PAUSE

22. Put the underwater unit of the STD in the water and set up the analog recorder. Press RUN. Data are punched from the high-speed punch while the unit is being lowered. No data are recorded while it is stopped or being raised.
23. When the specified maximum pressure is attained, the teletype prints CAST COMPLETED: APPARENTLY SUCCESSFUL. If for some reason the cast is to be halted earlier, set switch 15 up. Teletype prints CAST ABORTED: SEE LOG FOR REASONS. At the end of a cast, 4000 db, 0.0°C and 0.0‰ are punched on the data tape.
24. Press white button on tape punch to produce some leader. Turn off the equipment.
25. Rewind the data tape as it is wound with the beginning on the inside of the spool. Keep both the data tape and the teletype printout.
26. At the next station, if the computer has not been used for another program, turn on all equipment and begin at step 17.

Note: The program is loaded by the BASIC BINARY LOADER or ABSOLUTE BLOCK LOADER which is "permanently" stored in the computer's memory. If the tape is partially read and the computer halts with 102011 in the T-register, a checksum error has occurred. Release the tape in the photo-reader, slide it back to the beginning of the record, i.e., to the preceding gap of four feed holes, put tape guide back up to RUN, and press RUN. If computer halts again at the same place, check the tape for tears or dirt. If the tape looks all right, clean the photo-reader, and check that the tape guide is not loose. If it is, tighten the screw; there is a hole in the front of the casing so the screw can be reached easily.

If the tape is not read at all, it is likely that the ABSOLUTE BLOCK LOADER has been destroyed. For checking or restoring it, see Appendix D. When it has been restored, begin again at step 8.

4. Data processing program (WET)

4.1. Description

Program WET was written to process the STP data tapes obtained from DEEP. The program provides for: reading the data tapes; locating or interpolating for the pressure, temperature and salinity at standard pressures; calculating the depth, specific gravity anomaly, specific volume anomaly, geopotential anomaly and the potential energy at standard pressures, and printing out station heading data and parameter values at standard pressures on the teletype (Fig. 3).

Program WET (Table 4) reads the station heading data and prints them on the teletype; North and West are suffixed to the latitude and longitude respectively (the program was written for use in the North Pacific). Pressure, temperature and salinity data are read from the data tape, and each set of data is considered to be simultaneous. Pressure data are compared to standard pressures; when necessary, temperature and salinity are linearly interpolated to standard pressures. For each observed pressure the specific gravity anomaly and the specific volume anomaly are calculated in subroutines SIGMT and ALPHA (Table 5). The integrals depth, geopotential anomaly, and potential energy anomaly are computed using a linear integration scheme and listed with units of meters, J/kg, and 10^8 ergs/cm², respectively.

4.2. Operating procedures

These instructions are for the absolute binary tape of WET.

1. With computer off, check that interface boards of the peripheral units are in the input-output channels as in Table 1.
2. Turn on computer and photo-reader.
3. Place absolute binary tape of WET in the photo-reader with the narrow portion of the tape nearer the instrument. Thread the leader portion of the tape through the brake, under the hold-down spring and under the rubber roller. Raise the tape guides until RUN is exposed.
4. Set switch register to 17700 (switches 6-12 are up and switches 0-5 and 13-15 are down).
5. Press LOAD ADDRESS.
6. Set LOADER switch to ENABLED.
7. Press PRESET.
8. Press RUN. The tape is read through the photo-reader. When it stops the T-register should contain 102077. If not, see Note at the end of section 3.2.
9. Set LOADER switch to PROTECT.
10. Remove tape from photo-reader and rewind it.
11. Set teletype to LINE.
12. Set switch register to 2027 (switches 0-2, 4 and 10 up and all other switches down).

13. Place data tape in photo-reader, with about five feed holes before the first character.
14. Press LOAD ADDRESS.
15. Press RUN. Data tape is read and parameters at standard pressures are printed on the teletype. At the end of the tape the teletype prints LOAD NEXT TAPE, PUSH START, and then PAUSE. If the teletype prints *EQT before the data tape is read, there are too many feed holes before the first character.
16. Place next data tape in photo-reader, and rewind the previous tape. Press RUN. When last tape has been processed turn off the equipment.

If computer has not been used for any other program, more tapes may be processed by turning on computer, photo-reader and teletype and following the instructions beginning at step 12.

5. Appendix A - Preparing absolute binary tapes

Modifications to the programs or reconfiguration of the computing system necessitate a new absolute tape. It is assumed that configured standard software is available; if not, it is necessary to first prepare configured software (see Appendix B). The Fortran program is compiled in two passes. Compilation instructions are given in the operating manual.

The relocatable binary tapes may be used to produce an absolute binary tape as follows:

1. Place configured BASIC CONTROL SYSTEM in photo-reader. Set switch register to 17700. Press LOAD ADDRESS. Set LOADER switch to ENABLED. Press PRESET, RUN. Computer halts with 102077 in the T-register. Set LOADER switch to PROTECT.
2. Set switch register to 2 (switch 1 up, all other switches down). Press LOAD ADDRESS.
3. Put switches 14 and 15 up and all other switches down.
4. Turn high-speed punch on and teletype to line.
5. Place relocatable binary tape of main program in photo-reader. Press RUN. The tape is copied via the high-speed punch. When the tape has been read, the teletype prints LOAD and computer halts.

6. Load subroutines as follows:

For DEEP: Place relocatable binary tape of CAST in photo-reader. Press RUN. Teletype prints LOAD. Computer halts.

For WET: Place relocatable binary tape of ALPHA in photo-reader. Press RUN. Teletype prints LOAD. Place relocatable binary tape of SIGMT in photo-reader. Press RUN. Teletype prints LOAD. Computer halts.

7. Place binary tape of BAILEY CLOCK ROUTINE in photo-reader and push RUN. Teletype prints LOAD and computer halts.
8. Place binary tape of D.43 in photo-reader. Press RUN. Teletype prints LOAD and computer halts.
9. Set switch 2 up. Place LIBRARY tape in photo-reader and press RUN. Appropriate subroutines are copied onto the absolute tape by the computer. When finished, the teletype prints *LST.
10. If a listing of the memory locations is desired, set switch 15 down and push RUN (it is not usually required as it is automatically punched at the end of the absolute tape). Otherwise, simply push RUN. Teletype prints *END.

The absolute tape obtained from the high-speed punch can now be used until the system is reconfigured or until the tape wears out. If it is likely to be used much, it is advisable to duplicate it using PUNCH-VERIFY (see the system operating manual).

6. Appendix B - Reconfiguring the system

It may be desirable to change the I/O channels of the peripheral units, either due to altered priorities or due to an addition to the system. Some of the standard software must be configured. Instructions for configuring the BASIC CONTROL SYSTEM are given here; specific instructions for configuring FORTRAN and the SYMBOLIC EDITOR using SYSTEM INPUT/OUTPUT DUMP are given in the system operating manual.

A configured BASIC CONTROL SYSTEM is the result of running a program known as PREPARE CONTROL SYSTEM. An aid in using this is a "configuration diagram" (Fig. 4). Entries in Fig. 4 are for the system as used in May and October 1969. The interface cards are listed in order of the "interrupt location" which is the same as the input-output channel. The "driver identification" refers to the software driver for the peripheral unit (Table 1). Most drivers have an "interrupt" section which is available through the "linkage location" and the "interrupt identification". The

first linkage location is the octal number after the last interrupt location. If there is no interrupt section in the driver, constants are entered in the linkage location. For the digital voltmeter, this constant is zero, and for the data source interface and reed scanner the constant is 1067XX, where the last two digits are the I/O channel number. Unit reference numbers are shown in Fig. 4 in the row "equipment table" (see Table 1). Standard units are assigned by matching the standard functions with the equipment table.

The first word of available memory is the next octal number after the linkage locations. The last word of available memory is 17677 for an 8K system.

The entries in the configuration diagram are used to prepare responses to the teletype output of PREPARE CONTROL SYSTEM. Explicit directions to use PREPARE CONTROL SYSTEM are contained in the operating manual. The teletype output from PREPARE CONTROL SYSTEM is kept at the beginning of the system's software manuals.

7. Appendix C - The BAILEY CLOCK ROUTINE

This subroutine provides a time of day clock. It has entry points SETUP, CLOCK, .CLOCK, STCLK, RDCLK, DATIM and HALT which may be called from the main program. Before any other calls can be made, the time of day clock must be initialized by CALL SETUP. When this is executed, the routine will print ENTER TIME (HRS: MIN: SEC) and the operator will then enter the time of day plus a half minute or so. The operator types RETURN, LINE FEED, and the computer halts with 102077 in the T-register. When the operator pushes the RUN button, the real time of day will be maintained by the CLOCK entry point. The real time of day may be read by means of a CALL DATIM (IH, IM, IS) by which the time is returned in hours, minutes and seconds. The clock may be reset to zero by a CALL HALT. If the computer is halted by a PAUSE statement or by pressing the HALT button, the clock is stopped but not reset.

An integer clock is maintained by the routine .CLOCK. CALL STCLK(N) sets the clock to zero and causes it to be incremented every 10 n milliseconds. N must be an integer constant between 1 and 32,767. A CALL RDCLK(M) returns the integer number of intervals of 10 N milliseconds elapsed since the clock was set. The integer clock may be reset by another call to STCLK.

An assembly language listing of the BAILEY CLOCK ROUTINE is included in the system manuals.

8. Appendix D - the ABSOLUTE BLOCK LOADER

The ABSOLUTE BLOCK LOADER, also known as the BASIC BINARY LOADER, is a program stored in the sixty-four highest memory addresses (from 17700 to 17777). It is used to load all absolute binary programs. A switch on the front panel of the computer is used to protect this portion of memory during normal operation; before the ABSOLUTE BLOCK LOADER can be used, this switch must be set to ENABLED.

Occasionally, through errors in operation, some or all of the ABSOLUTE BLOCK LOADER can be lost from memory. When this occurs, it can be restored manually using the switch register and LOAD ADDRESS and LOAD MEMORY (see operating manual) or by using a "BOOTSTRAP LOADER" as follows:

1. Set switch register to 20.
2. Press LOAD ADDRESS.
3. Set switch register to each of the numbers listed; after each press LOAD MEMORY.

103712
102312
024021
102512
001727
103712
102312
024026
102412
170001
006004
024020

4. Set switch register to 20.
5. Place BOOTSTRAP tape in the photo-reader so that a short (about half inch) section of the tape without feed holes precedes the first character.
6. Set LOADER switch to ENABLE.
7. Press PRESET.
8. Press RUN.
9. When the tape stops press HALT.
10. Set switch register to 17763. Press LOAD ADDRESS. Set switch register to 103712. Press LOAD MEMORY.

11. Set switch register to 102312. Press LOAD MEMORY.
12. Set switch register to 17766. Press LOAD ADDRESS. Set switch register to 102512. Press LOAD MEMORY.
13. Set LOADER switch to PROTECT.

The ABSOLUTE BLOCK LOADER is restored.

References

- Brown, N. L. 1964. An in situ salinometer for use in the deep ocean. Inst. Soc. Am., Pittsburgh, Pa., preprint 8.2-3-64. 11 p.
- Collins, C. A. 1969. A note on depth measurement and conversion from frequency to parameter value with Bissett-Berman STD's. Report to file - 1969-4, Pacific Oceanographic Group. 2 p.
- Gaul, R. D. 1968. Performance analysis of a salinity/temperature/depth system. IEEE Trans Geoscience Electronics GE-6(4): 185-189.

List of Tables

- Table 1. Equipment table of the computing system, showing the peripheral equipment, names of the software drivers, unit reference numbers, and input-output channel numbers.
- Table 2. Fortran listing of program DEEP.
- Table 3. Fortran listing of program CAST.
- Table 4. Fortran listing of program WET.
- Table 5. Fortran listing of subroutines ALPHA and SIGMT.

Table 1. Equipment table of the computing system, showing the peripheral equipment, the names of the software "drivers", unit reference numbers and input-output channel numbers.

Peripheral equipment	Driver name	Unit reference number	I/O channel number
Data source interface from digital voltmeter	D.40	7	13
Program interface for digital voltmeter	D.41	10	15
Photo-reader	D.01	11	12
High-speed punch	D.02	12	16
Teletype	D.00	13	11
Time base generator	D.43	14	10
Reed scanner	D.42 B	15	14

Table 2.

```
PROGRAM DEEP
C
C PROGRAM TO DIGITIZE AN STD CAST AND EDIT THE DATA
C DATA COMPENSATED FOR TIME RESPONSE OF TEMPERATURE PROBE
C PUNCHES ONLY AFTER A PRESSURE INCREASE
C TO HALT PROGRAM PRIOR TO ATTAINING ASSIGNED PRESSURE,
C SWITCH 15 = 1
C
C STD MODEL 9006 (FRB#1); SALINITY SCALE 27.00 TO 37.00
C
C ENTER HEADING DATA
C CALL SETUP
10 WRITE(2,30)
   READ(1,*)ICRN
   WRITE(2,31)
   READ(1,*)ICON
   WRITE(2,32)
   READ(1,*)IYR,IMO,IDAY
   WRITE(2,33)
   READ(1,*)ILAT,XLAT
   WRITE(2,34)
   READ(1,*)ILONG,XLONG
   WRITE(2,35)
   READ(1,*)TI
   CALL DATIM(IH,IM,IS)
   IGMT=100*IH+IM
   WRITE(2,38)
   READ(1,*)IPMAX
   WRITE(4,36)ICRN,ICON,IYR,IMO,IDAY,TI,IGMT,ILAT,XLAT,
1  ILONG,XLONG
   WRITE(2,39)
   PAUSE
C
C BEGIN DIGITIZING
C
C 1 CALL CAST(P0,T0,S0)
C 2 IPO=P0-2.4
C
C NOTE THAT CONSTANT 2.4 = 2.9 -0.5
C 0.5 IS FOR ROUNDOFF
C 2.9 IS A ZERO PRESSURE ADJUSTMENT
C
C IF (IPO)1,12
12 SUMT=T0
   SUMS=S0
   K=1
   J=1
   IT=100.*TI
   CALL STCLK(IT)
C
C READ NEXT VALUE
C
C 3 CALL RDCLK(M)
C 4 CALL CAST(P1,T1,S1)
```

```
J=J+1
IP1=PI-2.4
C TEST FOR CAST COMPLETION
  IF(IP1-IPMAX)7,80
C TEST FOR ABORTED CAST
  7 IF(ISSW(15))81,13
C CORRECT DATA FOR RESPONSE TIME OF TEMPERATURE SENSOR
13 S1=S1+0.35*(T1-T0)/TI
   T1=T1+0.35*(T1-T0)/TI
   IF(IP1-IPO)11,5,6
C AVERAGE TEMPERATURES AND SALINITIES OBSERVED AT SAME PRESSURE
  5 SUMT=SUMT+T1
   SUMS=SUMS+S1
   K=K+1
   GO TO 3
  6 C=K
   T=SUMT/C
   S=SUMS/C
C ROUND OFF AND OUTPUT THE DATA
  T=T+0.005
  S=S+0.005
  WRITE(4,37)IPO,T,S
C RE-INITIALIZE
  IPO=IP1
  K=1
  SUMT=T1
  SUMS=S1
  SO=S1
11 T0=T
   GO TO 3
C CAST ENDED
80 WRITE(2,40)
   GO TO 90
81 WRITE(2,41)
   GO TO 90
83 WRITE(2,43)
C PROVIDE ENDING FOR DATA TAPE
90 IPX=4000
   TX=0.
   SX=0.
   WRITE (4,37)IPX,TX,SX
   PAUSE
   GO TO 10
30 FORMAT("CRUISE NUMBER")
31 FORMAT("CONSECUTIVE STATION NUMBER")
32 FORMAT ("DATE (YEAR, MONTH, DAY)")
33 FORMAT("LATITUDE - DEGREES MINUTES")
```

```
34 FORMAT("LONGITUDE - DEGREES MINUTES")
35 FORMAT ("TIME INTERVAL BETWEEN READINGS IN SEC")
36 FORMAT(5I5,F5.2, I5, I4,F6.2, I4,F6.2)
37 FORMAT(I5,2F7.2)
38 FORMAT("MAXIMUM PRESSURE TO BE OBSERVED")
39 FORMAT("WHEN READY TO BEGIN CAST PUSH RUN")
40 FORMAT("CAST COMPLETED; APPARENTLY SUCCESSFUL")
41 FORMAT("CAST ABORTED: SEE LOG FOR REASONS")
43 FORMAT("TIME INTERVAL BETWEEN READINGS IS TOO SHORT")
  END
```

Table 3.

```

SUBROUTINE CAST(P,T,S)
DIMENSION DATA(3)
C
C TO DIGITIZE STD DATA
C PROGRAM READS FREQUENCIES FROM THE DVM AND
C CONVERTS DATA TO THE USUAL UNITS
C
C SCANNER CHANNELS ARE ASSIGNED AS FOLLOWS:
C CHANNEL 1 - PRESSURE
C CHANNEL 2 - TEMPERATURE
C CHANNEL 3 - SALINITY
C
C UNIT REFERENCE NUMBERS FOR DVM, SCANNER, AND DATA INTERFACE
IDVM=10B
ISCNR=15B
IDSI=7B
C
C READ THE FREQUENCIES
C
DO 100 J=1,3
C REMOVE HOLD-OFF
WRITE(IDSI)
C PROGRAM THE DVM
IPGM=20B
WRITE(IDVM) IPGM
C PROGRAM THE SCANNER
ICHAN=J
ISPGM=1B
WRITE(ISCNR) ICHAN, ISPGM
C TAKE THE READING
100 READ(IDSI,25)DATA(J)
25 FORMAT(2X,E10.0,4X)
C
C CONVERT FREQUENCIES TO DECIBARS, DEGREES CELSIUS AND
C PARTS PER MILLE
C
P=(DATA(1)*1000.-9712.)*.95676
T=(DATA(2)*1000.-2127.)*37./2066.-2.
S=(DATA(3)*1000.-4995.)/290.6+27.
RETURN
END
```

Table 4.

```
FTN,L,B
C
C
C PROGRAM FOR FINAL SHIPBOARD PROCESSING OF STD
C DATA
C
C PROGRAM WET
C DIMENSION ISTD(22)
C INITIALIZATION
  IP=0
  I=1
  I1=0
  ISTD(1)=0
  ISTD(2)=10
  ISTD(3)=20
  ISTD(4)=30
  ISTD(5)=50
  ISTD(6)=75
  ISTD(7)=100
  ISTD(8)=125
  ISTD(9)=150
  ISTD(10)=175
  ISTD(11)=200
  ISTD(12)=225
  ISTD(13)=250
  ISTD(14)=300
  ISTD(15)=400
  ISTD(16)=500
  ISTD(17)=600
  ISTD(18)=800
  ISTD(19)=1000
  ISTD(20)=1200
  ISTD(21)=1500
  ISTD(22)=3000
C READ HEADER INFORMATION
14 READ(5,*)ICRNO,ICON,IYR,IMO,IDAY,TI,IGMT,ILAT,XLAT,
  1 I LONG,XLONG
  WRITE(2,100)ILAT,XLAT,ILONG,XLONG,IMO,IDAY,IYR,IGMT,
  1 IYR,ICRNO,ICON
100 FORMAT("PACIFIC OCEANOGRAPHIC GROUP"/"LAT ",I2,"-",
  1F4.1,"N", " LONG ",I3,"-",F4.1,"W"/"DATE "I2,"-",I2,
  2"-",I2," GMT ",I4/"REFERENCE NO. ",I2,"-",I3,"-",I3/
  3"RESULTS OF STP CAST"/"PRESS TEMP SAL DEPTH
  4IGMA SVA DEL POT"/32X,"T",I3X,"D EN.")
  YLAT=ILAT
  YLAT=YLAT+XLAT/60.
  GRAV=(YLAT*YLAT*(-YLAT*1.4189E-7)+1.9155E-5)+9.78030
  GRAV=GRAV*0.1
  Z=0.0
  DELD=0.0
  PE=0.0
C
```

```
C   READ DATA FROM PUNCHED PAPER TAPE
1   READ(S,*)P,T,S
C   INTERPOLATE IF NECESSARY
12  IF(P)1,2,3
3   PO=P
    TO=T
    SO=S
    I1=1
    IP=1
    P=0.
    GO TO 2
13  READ(S,*)P,T,S
    IF(T)11,11,2
2   IPOBS=P
    IF(ISTD(I)-IPOBS)4,5,6
4   PO=P
    TO=T
    SO=S
    I1=1
    P=ISTD(I)
    IPOBS=ISTD(I)
    I=I+1
    S=((SO-S1)*(P-P1)/(PO-P1))+S1
    T=((TO-T1)*(P-P1)/(PO-P1))+T1
    IP=1
    GO TO 6
5   IP=1
    I=I+1
C   COMMENCE PROCESSING DATA
6   CALL SIGMT(0.,35.,S02,SIG2)
    DIJMMY=ALPHA(0.,S02,P,SIG2)
    CALL SIGMT(T,S,S01,SIGMA)
    A=ALPHA(T,S01,P,SIGMA)
    SVA=A-DIJMMY
    IF(IPOBS)15,16,15
15  Z=Z+(P-P1)*(A+A1)/(2.*GRAV)
    DELD=DELD+0.5*(SVA+SVA1)*(P-P1)
    PE=PE+0.5*(P*SVA+P1*SVA1)*(P-P1)/GRAV
C   LIST DATA AT STANDARD PRESSURES
16  IF(IP)7,7,8
8   IP=0
    IF(I1)9,9,17
17  T=T+0.005
    S=S+0.005
9   IZOUT=Z+0.5
    SIGMA=SIGMA+0.005
    SVOUT=1.E05*SVA+0.05
    DOUT=(DELD+0.005)*10.
    PEOUT=PE*0.1+0.005
    WRITE(2,101)IPOBS,T,S,IZOUT,SIGMA,SVOUT,DOUT,PEOUT
101 FORMAT(15,F7.2,F8.2,I7,F8.2,F7.1,F7.1,F7.2)
C
```

C RE-INITIALIZE

```
7 P1=P
  T1=T
  S1=S
  SVA1=SVA
  A1=A
  IF(I1)13,13,10
10 P=P0
  S=S0
  T=T0
  IPOBS=P
  I1=0
  GO TO 6
11 WRITE(2,102)
102 FORMAT(////////)
  WRITE(2,103)
103 FORMAT("LOAD NEXT TAPE, PUSH START")
  PAUSE
  WRITE(2,102)
  I=1
  GO TO 14
END
END$
```

Table 5.

FTN,L,B

C
C
C

SPECIFIC VOLUME - ALPHA

```
FUNCTION ALPHA(T,S0,P,SIGMA)
S0=0.1*(S0-28.)
T1=4886./(1.+1.83E-5*P)
T2=227.+28.33*T-0.551*T*T+0.004*T*T*T
T3=P*1.E-4*(105.5+9.50*T-0.158*T*T)-1.5E-8*T*P*P
T4=147.3-2.72*T+0.04*T*T-P*1.E-4*(32.4-0.87*T+0.02*T*T)
T5=4.5-0.1*T-P*1.E-4*(1.8-0.06*T)
XMIJ=T1-T2+T3-S0*T4+S0*S0*T5
XMIJ=XMIJ*1.E-9
ALPHA=(1.-XMIJ*P)/(SIGMA*1.E-3+1.)
RETURN
END
ENDS
```

FTN,L,B

C
C
C

SUBROUTINE SIGMT(T,S,S0,SIGMA)
SPECIFIC GRAVITY ANOMALY

```
S0=-0.0934+0.8149*S-0.000482*S*S+6.8E-6*S*S*S
BT=T*(18.03-0.8164*T+0.01667*T*T)/1.E+6
AT=T*(4.7867-0.098185*T+0.0010843*T*T)/1000.
ET=(((-T-3.98)**2)/503.57)*((T+283.)/(T+67.26))
SIGMA=ET+(S0+0.1324)*(1.-AT+BT*(S0-0.1324))
RETURN
END
ENDS
```

List of Figures

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- Fig. 4. The "configuration diagram" for the computing system as used in May and October, 1969.

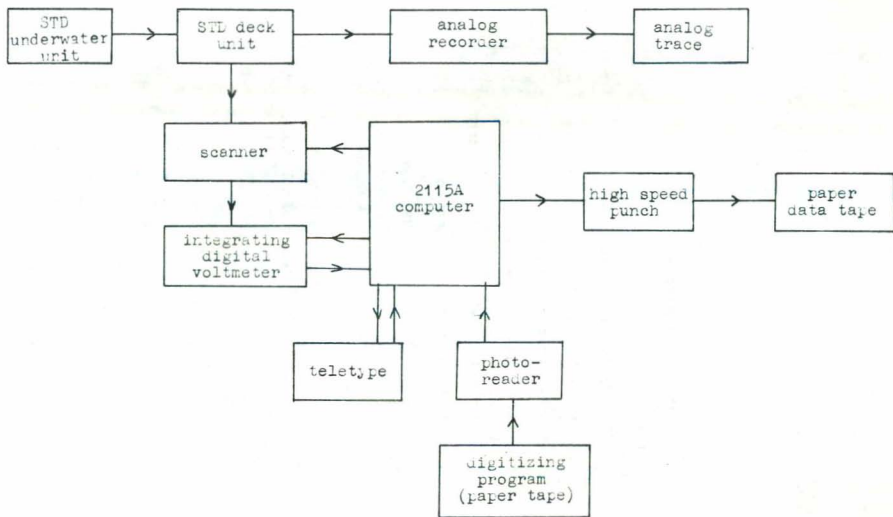


Fig. 1. Block diagram of the salinity-temperature-pressure digitizing system.

```
ENTER TIME (HRS: MIN: SEC)
09 15 00
CRUISE NUMBER
004
CONSECUTIVE STATION NUMBER
25
DATE (YEAR, MONTH, DAY)
69 05 21
LATITUDE - DEGREES MINUTES
50 00
LONGITUDE - DEGREES MINUTES
145 00
TIME INTERVAL BETWEEN READINGS IN SEC
4
MAXIMUM PRESSURE TO BE OBSERVED
1530
WHEN READY TO BEGIN CAST PUSH RUN
PAUSE
```

Fig. 2. The requesting and entering of STP Station heading data via the teletype with program DEEP.

PACIFIC OCEANOGRAPHIC GROUP
 LAT 48-42.0N LONG 126-40.0W
 DATE 5-17-69 GMT 1630
 REFERENCE NO. 69- 4- 5
 RESULTS OF STP CAST

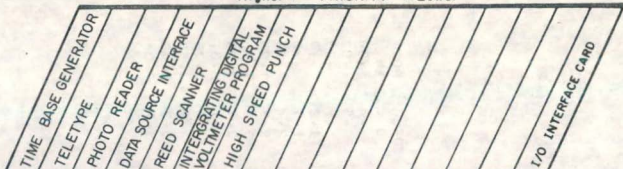
PRESS	TEMP	SAL	DEPTH	SIGMA T	SVA	DEL D	POT EN.
0	11.62	31.31	0	23.82	409.8	.0	.00
10	11.52	31.26	10	23.80	411.6	.5	.03
20	10.46	31.53	20	24.20	374.3	.9	.09
30	9.20	32.22	30	24.94	303.4	1.2	.17
50	7.76	32.44	50	25.32	267.3	1.7	.40
75	7.72	33.00	75	25.77	225.2	2.4	.81
100	8.39	33.73	100	26.24	181.1	2.9	1.25
125	8.18	33.79	125	26.33	173.5	3.3	1.76
150	7.46	33.81	150	26.44	162.9	3.7	2.36
175	7.58	33.97	175	26.55	152.8	4.1	3.01
200	7.22	33.96	200	26.59	149.1	4.5	3.75
225	7.05	33.97	225	26.63	145.9	4.9	4.55
250	6.81	33.98	249	26.67	142.5	5.3	5.43
300	6.16	34.02	299	26.78	132.1	5.9	7.36

Fig. 3. Sample output of program WET.

FIRST WORD OF AVAILABLE MEMORY (FWAM) 23

LAST WORD OF AVAILABLE MEMORY (LWAM) 17677

Higher ← PRIORITY → Lower



DRIVER IDENTIFICATION	D-43	D-00	D-01	D-40	D-42B	D-41	D-02										
INTERRUPT LOCATION	10	11	12	13	14	15	16	17	20	21	22	23	24	25	26	27	
LINKAGE LOCATION	17	20	21	10673	10674	0	22										
INTERRUPT IDENT.	I-43	I-00	I-01	-	-	-	I-02										
EQUIPMENT TABLE →	14	13	11	7	15	10	12										

STANDARD UNIT TABLE																		
1.	KEYBOARD INPUT		✓															
2.	TELEPRINTER OUTPUT		✓															
3.	PROGRAM LIBRARY			✓														
4.	PUNCH OUTPUT						✓											
5.	INPUT			✓														
6.	LIST OUTPUT		✓															

NOTE: ASSIGN STANDARD UNITS BY PLACING A CHECKMARK AT THE CORRECT X-Y INTERSECTION.

Fig. 4. The "configuration diagram" for the computing system as used in May and October, 1969.